Liquid Nitrogen Historical and Current Usage of the Central Helium Liquefier at Spallation Neutron Source

B. DeGraff, M. Howell, S. Kim, and T. Neustadt

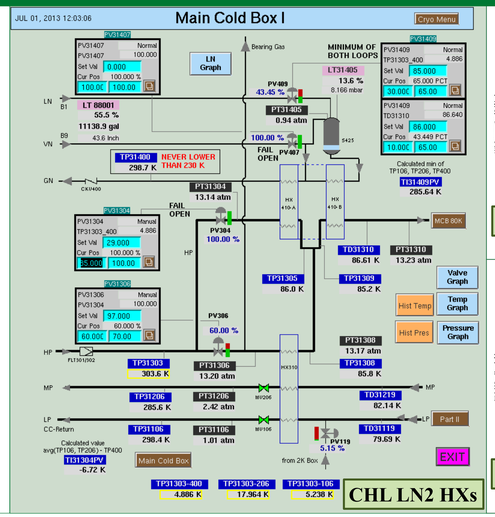
INTRODUCTION

Liquid nitrogen is supplied from a 20,000 gallon storage Dewar to two points in the SNS cryogenic system:

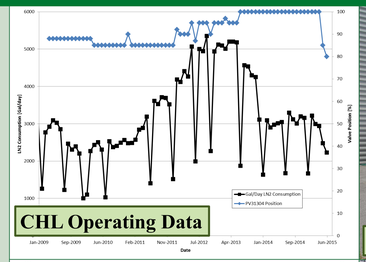
1. Nitrogen helium heat exchanger within the 4-K cold box.
2. Provide cooling for the motors of the cold compressors located inside the 2-K cold box. The saturated vapor exhaust from 2-K cold box is returned through the 4-K cold box

The high pressure helium entering the cold box has two different paths available for cooling:

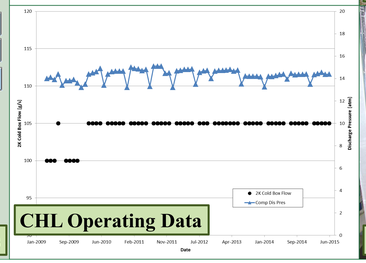
1. Helium flow through the PV31306 is cooled first by the returning cold helium before being cooled by the nitrogen HX 410-B
2. Helium flow that goes through the PV31304 is cooled first by the nitrogen vapor in HX 410-A, before rejoining the main high pressure flow and being cooled by the two phase nitrogen flow in HX 410-B.



CHL LN2 HXs



CHL Operating Data



CHL Operating Data

CHL LN2 Dewar

CHL 4-K Cold Box

CHL 2-K Cold Box

ABSTRACT

Design and operation of liquid nitrogen (LN2) supplied from a single 20,000-gallon supply Dewar will be discussed. LN2 used to precool the 4-K cold box heat exchanger started to increase around 2011. LN2 Consumption during 2012 and 2013 was almost double the nominal usage rate. Studies of this data, plant parameter changes to respond to this information, and current interpretations are detailed in this paper. The usage rate of LN2 returned to normal in late 2013 and remained there until recent additional changes. Future study plans to understand potential causes of this including contamination migration within the 4-K cold box will also be addressed.

ACKNOWLEDGEMENTS

The authors would like to thank many colleagues at both SNS and TJNAF for their assistance in performing the testing described in this paper. This work was supported by SNS through UT-Battelle, LLC, under contract DE-AC05-00OR22725 for the U.S. DOE.

2013 LN2 STUDIES

<u>At the beginning of 2013, it was discovered that the SNS cryogenic system was using more LN2 than the normal usage of about 3000 gallons per day.</u> There appear to be three distinct periods from 2009 to 2013:

1. LN2 nominal usage is relatively constant before 2011
2. In 2011, the LN2 usage started to climb in a somewhat linear manner from 3000 gallons a day to over 5000 gallons a day
3. LN2 usage rate appears to be constant up to studies period in 2013

No contamination observed on LINDE gas analyser (O_2, N_2, Oil & Oil Vapor)

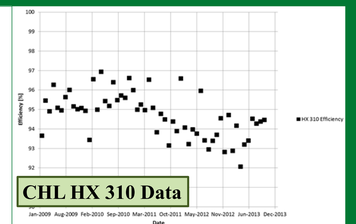
Testing period in 2013 was conducted with goal of restoring LN2 usage:

- Adjusting PV31409 loop set point
- Several changes to PV31306 and PV31304 valve positions

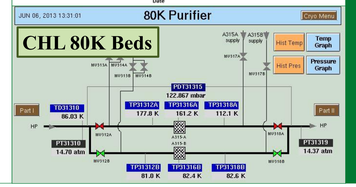
Results of the testing week:

- No change in LN2 consumption when PV31409 set point was adjusted to match readings in 80 K beds
- Nominal positions of PV31306 at ~65% and PV31304 at ~95% were fixed at 60% and 100% respectively and yielded a usage rate at end of testing at 4500 gallons per day

Usage continued to drop for ~6 months



CHL HX 310 Data



CHL 80K Beds

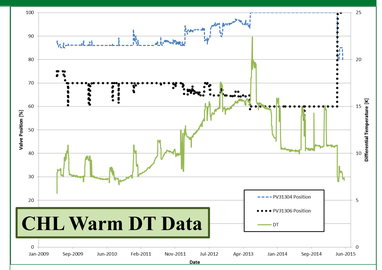
CURRENT LN2 STUDIES

Testing period in 2015 was conducted with goal of optimizing LN2 usage:

- Minimize differential temperature between high and medium pressure helium circuits at warm end of 4-K cold box.

Results of testing week:

- PV31304 was fixed at 80% and PV31306 was fixed at 100%.
- T1 turbine inlet valve opened from ~70% to ~85%
- No change in 2nd stage compressor bypass flow
- Usage decreased to 2200 gallons per day



CHL Warm DT Data

Future experiments are being planned to study the possibility of having contamination migrate around inside a continuously cold LN2 cooled helium heat exchanger.

CONCLUSIONS

Testing of the LN2 & Helium valves was critical to restoring LN2 consumption by the 4-K cold box.

- First testing decreased the LN2 usage rate by 39% or 2100 gallons of liquid nitrogen per day
- The second changes made to PV31304 and PV31306 further reduced the LN2 consumption by another 32% or 1000 gallon of liquid nitrogen per day
- HX 310 has degraded, but the source of the HX 310 degradation has not been determined
- The cause of the original rise in CHL LN2 consumption has not been determined by testing
- Future experimentation utilizing the custom Dewar will help determine the cause of the 2012 increase in nitrogen usage